

SECTION 1028 -- SUPERPAVE ASPHALTIC CONCRETE

1028.01 -- Description

1. a. Superpave Asphaltic Concrete is a Contractor-designed mix.
 - b. The Contractor will be required to define properties using a gyratory compactor that has met the Superpave evaluation test procedures, during mix design and production.
2. a. Before production of asphaltic concrete, the Contractor shall submit, in writing, a tentative job mix formula for approval to the NDR Flexible Pavement Engineer at the Lincoln, Nebraska Central Laboratory.
 - b. The job mix formula shall identify the mineral aggregates and mineral filler, if needed, with the value of the percent passing each specified sieve for the individual and blended materials.
 - c. (1) The Contractor shall submit 6 gyratory pucks prepared for moisture susceptibility and 3 proportioned 20 lb. (10,000-gram) samples of the blended mineral aggregates to be used in the mixture to the NDR Materials and Research Central Laboratory at least 10 NDR working days before production of asphaltic concrete. These samples will be used to correlate the Contractor's Superpave mix design test results.
 - (2) Submitted with these samples shall be a copy of the Contractor's results for all Superpave mix design tests.
 - (3) This mix design shall include at a minimum:
 - (i) The bulk specific gravity of the blended aggregate. (The bulk specific gravity shall be determined from an unwashed sample.)
 - (ii) The target binder content.
 - (iii) The supplier and grade of PG Binder.
 - (iv) The maximum specific gravity of the combined mixture (Rice).
 - (v) The average bulk specific gravity and air voids at N initial (Nini), N design (Ndes) and N maximum (Nmax) of the compacted gyratory specimens.
 - (vi) Voids in the Mineral Aggregate (VMA) and Voids Filled with Asphalt (VFA) at Ndes.
 - (vii) Fine Aggregate Angularity (FAA), Coarse Aggregate Angularity (CAA), Flat and Elongated Particles and Clay Content of the aggregate blend.
 - (viii) Location description and/or legal descriptions and producers of materials used in the mix.
 - d. Before the mix design is approved, the Materials and Research Laboratory shall verify all properties.

3. PG Binder in Recycled Asphalt Pavement:

a. The Contractor may approach the State with a proposal to supplement the virgin aggregates of the asphaltic concrete mix with a Contractor's specified percentage of recycled asphalt pavement (RAP). The State may accept or reject the proposal based on whether the mix design meets the specified criteria of the asphaltic concrete proposed. The RAP may come from the project or an existing stockpile. The Contractor is responsible for investigating the quality and quantity of the RAP material.

b. In recycled asphaltic concrete mixtures, the allowable maximum percent of Reclaimed Asphalt Pavement (RAP) will be as shown in Table 1028.01. If the Contractor elects to exceed these values, the Contractor will be required to lower the minimum pavement design temperature of the PG Binder, one grade, according to AASHTO MP1.

Table 1028.01

Asphaltic Concrete Type	Percent, Maximum RAP
SPS	50
SP0	45
SP1	35
SP2	25
SP3	25
SP4	15
SP5	15

4. Quality Control Program:

a. The Contractor shall establish, provide, and maintain an effective Quality Control(QC) Program. The QC Program shall detail the methods and procedures that will be taken to assure that all materials and completed construction conforms to all contract requirements.

b. Although guidelines are established and certain minimum requirements are specified herein and elsewhere in the contract, the Contractor shall assume full responsibility for placing a pavement course that meets the target field values.

c. The Contractor shall establish a necessary level of control that will:

(1) Adequately provide for the production of acceptable quality materials.

(2) Provide sufficient information to assure both the Contractor and the Engineer that the specification requirements can be met.

(3) Allow the Contractor as much latitude as possible in developing control standards.

d. (1) The Contractor shall develop and provide the Engineer a copy of the QC Program no less than 10 NDR working days prior to the preconstruction conference or no less than 10 NDR working days prior to beginning production of project materials.

(2) The Contractor shall not begin any construction or production of materials until the Engineer has approved the QC Program.

e. The QC Program shall address, as a minimum, the following items:

(1) QC organization chart.

(2) The mix design.

(3) Submittals schedule.

(4) Inspection requirements.

(i) Equipment.

(ii) Asphalt concrete production.

(iii) Asphalt concrete placement.

(5) QC testing plan.

(6) Documentation of QC activities.

(7) Requirements for corrective action when QC and/or acceptance criteria are not met.

(8) Any additional elements deemed necessary.

(9) A list, with the name and manufacturers model number, for all test equipment used during laboratory testing.

(10) A description of maintenance and calibration procedures, including the frequency that the procedures are performed.

f. The QC organization chart shall consist of the following personnel:

(1) A Program Administrator:

(i) The Program Administrator shall be a full-time employee of the Contractor or a Subcontractor (Consultant) hired by the Contractor.

(ii) The Program Administrator shall have a minimum of 5 years experience in highway construction.

(iii) The Program Administrator need not be on the job site at all times but shall have full authority to institute any and all actions necessary for the successful implementation of the QC Program.

(iv) The Program Administrator's qualifications and training shall be described in the QC Program.

(2) One or more Quality Control Technicians:

(i) The quality control technicians shall report directly to the Program Administrator and shall perform all quality control tests as required by the contract.

(ii) The QC technicians shall be certified by the NDR Materials and Research Division.

(iii) Certification at an equivalent level by a state or nationally recognized organization may be acceptable.

(iv) The QC technician's credentials and NDR training records shall be submitted to the NDR Materials and Research Division.

(v) The Contractor may have a non-certified technician working under the direct supervision of a certified technician for no more than one construction season.

g. (1) Inspections shall be performed daily to ensure continuing compliance with contract requirements until completion of the work.

(2) QC test results and periodic inspections shall be used to ensure the mix quality and to adjust and control mix proportioning.

h. QC Testing Plan:

(1) The testing plan shall include the NDR statistically based procedure of random sampling for acquiring test samples.

(2) The Contractor may add any tests necessary to adequately control production.

(3) All QC test results shall be documented by the Contractor with a copy provided to the Engineer within 1 week after the tests are complete. Daily review by the Engineer will be allowed if requested.

(4) Copies of all forms to be used shall be included in the QC Testing Plan.

i. Corrective Action Requirements:

(1) The Contractor shall establish and utilize QC charts for individual QC tests. The requirements for corrective action shall be linked to the control charts.

(2) The Contractor's QC Program shall detail how the results of QC inspections and tests will be used to determine the need for corrective action.

(3) (i) A clear set of rules to determine when a process is out of control and the type of correction to be taken to regain process control will be provided.

(ii) As a minimum, the plan shall address the corrective actions that will be taken when measurements of the following items or conditions approach the specification limits:

(I) Plant produced mix gradations at laydown.

(II) Binder content.

(III) Air voids.

(IV) VMA

(V) VFA

(VI) FAA AASHTO T 304
 CAA ASTM D 5821

(iii) Corrective actions that will be taken when the following conditions occur:

- (I) Rutting
- (II) Segregation
- (III) Surface voids

1028.02 -- Material Characteristics

1. The type of PG Binder shall be shown in the plans or special provisions.

2. Aggregates:

a. Aggregates for use in superpave asphaltic concrete shall be tested on an individual basis.

b. With the exception of Asphaltic Concrete Type SPS the blended mineral aggregate shall not contain more than 60 percent limestone on the final surface lift of asphaltic concrete.

c. Crushed rock material for use in asphaltic concrete, 1/4 inch (6.35 mm) down, screenings and manufactured sand shall have a Sodium Sulfate loss of not more than 12 percent by mass at the end of 5 cycles. One 20-lb. (10-kg) sample shall be taken by NDR personnel at the project for every 5,000 tons (4500 Mg) of aggregate used, with a minimum of one per project for quality testing.

d. Quartzite, granite, and chat shall conform to the requirements of Subsection 1033.02, Paragraph 4, a. (8). One 60-lb. (30 kg) sample shall be taken by NDR personnel at the project every 3,000 tons (2700 Mg) of aggregate used, with a minimum of one per project for quality testing.

e. Crushed rock (Limestone) and Dolomite shall conform to the requirements of Subsection 1033.02, Paragraph 4.a. (4), (5) and (6). Sampling size and frequency shall adhere to the current NDR Materials Sampling Guide. (Dolomitic aggregate can be adversely affected by burn ovens resulting in erroneous reading for asphalt content and gradation unless corrected for.)

f. Amend Paragraph 4.a. (7) of Subsection 1033.02 to provide that soundness tests shall not be required for fine sand.

g. Amend Subsection 1033.02 to provide that once the satisfactory quality of aggregates from a source has been established, sufficient additional soundness tests will be performed to insure the continued satisfactory quality of the material.

h. The coarse aggregate angularity value of the blended aggregate material shall meet or exceed the minimum values for the appropriate asphaltic concrete type shown in these provisions and position within the pavement structure according to Table 1028.02.

**Table 1028.02
Coarse Aggregate Angularity
(ASTM D 5821)**

Asphaltic Concrete Type	Depth from the Surface	
	4 inches (100 mm) or less	Greater than 4 inches (100 mm)
SPS	35	--
SP0	55	--
SP1	55	--
SP2	65	--
SP3	75	50
SP4	85/80*	60
SP5	95/90*	80/75*

* Denotes two faced crushed requirements

(1) For any asphaltic concrete that is placed at a depth greater than 4 inches (100 mm) from the surface, the Contractor shall have the option of using the more stringent requirements under the coarse aggregate angularity heading "4 inches (100 mm) or less", for the full depth of the Superpave mixture.

i. The fine aggregate angularity value of the blended aggregate material from the fine and coarse aggregates shall meet or exceed the minimum values for the appropriate asphaltic concrete type shown in these provisions and position within the pavement structure according to Table 1028.03.

Note: The specific gravity for calculation of the Fine Aggregate Angularity (FAA) shall be based on material passing the No. 8 (2.36 mm) sieve and retained on the No. 100 (150 µm) sieve.

**Table 1028.03
Fine Aggregate Angularity
(AASHTO T304 Method A)**

Asphaltic Concrete Type	Depth from the Surface	
	4 inches (100 mm) or less	Greater than 4 inches (100 mm)
SPS	--	--
SP0	--	--
SP1	40	--
SP2	40	40
SP3	40	40
SP4	45	43
SP5	45	45

(1) For any asphaltic concrete that is placed at a depth greater than 4 inches (100 mm) from the surface, the Contractor shall have the option

of using the more stringent requirements under the fine aggregate angularity heading "4 inches (100 mm) or less", for the full depth of the Superpave mixture.

j. The coarse aggregate shall not contain flat and elongated particles exceeding the maximum value for the appropriate asphaltic concrete type category shown in these provisions according to Table 1028.04.

**Table 1028.04
Flat and Elongated Particles
(ASTM D 4791)**

Asphaltic Concrete Type	Percent, Maximum
SPS	25
SP0	10
SP1	10
SP2	10
SP3	10
SP4	10
SP5	10

Criterion based on a 5:1 maximum to minimum ratio.

k. The sand equivalent of the blended aggregate material from the fine and coarse aggregates shall meet or exceed the minimum values for the appropriate asphaltic concrete type shown in these provisions according to Table 1028.05.

**Table 1028.05
Clay Content Criteria
(AASHTO T 176)**

Asphaltic Concrete Type	Sand Equivalent, Minimum
SPS	30
SP0	40
SP1	40
SP2	40
SP3	45
SP4	45
SP5	45

l. The blended aggregate shall conform to the gradation requirements specified below for the appropriate nominal size.

(1) It is recommended that the selected blended aggregate gradation does not pass through the restricted zones as specified in the following control points for nominal size. Superpave mix designs with FAA

values less than 45 will not be approved if the blended aggregate gradation passes through the restricted zone.

Table 1028.06
Gradation Control Points for 0.375 Inch (9.5 mm) Nominal Size

English Sieve (Metric)	Control Points (percent passing)		Restricted Zone Boundary (percent passing)	
	Minimum	Maximum	Minimum	Maximum
1/2 inch (12.5 mm)	100.0			
3/8 inch (9.5 mm)	90.0	100.0		
No. 4 (4.75 mm)		90.0		
No. 8 (2.36 mm)	32.0	67.0	47.2	47.2
No. 16 (1.18 mm)			31.6	37.6
No. 30 (600 µm)			23.5	27.5
No. 50 (300 µm)			18.7	18.7
*No. 200 (75 µm)	2.0	10.0		

* see note following Table 1028.08

Table 1028.07
Gradation Control Points for 0.5 Inch (12.5 mm) Nominal Size

English Sieve (Metric)	Control Points (percent passing)		Restricted Zone Boundary (percent passing)	
	Minimum	Maximum	Minimum	Maximum
3/4 inch (19 mm)	100.0			
1/2 inch (12.5 mm)	90.00	100.00		
3/8 inch (9.5 mm)		90.00		
No. 8 (2.36 mm)	28.0	58.0	39.1	39.1
No. 16 (1.18 mm)			25.6	31.6
No. 30 (600 µm)			19.1	23.1
No. 50 (300 µm)			15.5	15.5
* No. 200 (75 µm)	2.0	10.0		

* see note following Table 1028.08

Table 1028.08
Gradation Control Points for 0.75 Inch (19 mm) Nominal Size

English Sieve (Metric)	Control Points (percent passing)		Restricted Zone Boundary (percent passing)	
	Minimum	Maximum	Minimum	Maximum
1 inch (25 mm)	100.0			
3/4 inch (19 mm)	90.0	100.0		
1/2 inch (12.5 mm)		90.0		
No. 8 (2.36 mm)	23.0	49.0	34.6	34.6
No. 16 (1.18 mm)			22.3	28.3*
No. 30 (600 µm)			16.7	20.7
No. 50 (300 µm)			13.7	13.7
* No. 200 (75 µm)	2.0	8.0		

* Dust to binder ratio is the ratio of the percentage by weight of aggregate finer than the No. 200 (75 µm) sieve to the effective asphalt content expressed as a percent by weight of total mix. Effective asphalt content is the total asphalt used in the mixture less the percentage of absorbed asphalt. The dust to binder ratio shall be between 0.6 and 1.2. This shall be verified during mix design approval.

m. The combined mineral aggregate for Asphaltic Concrete, Type SPS, shall be an aggregate or a combination of aggregates, and mineral filler if needed. The field target air voids shall be a minimum of 1.5 percent with maximum field air voids of 5.0 percent, based on the moving average of four tests.

Table 1028.09
Gradation Control Points for Type SPS

English Sieve (Metric)	Control Points (percent passing)	
	Minimum	Maximum
1 inch (25 mm)	100.0	
3/4 inch (19 mm)	94	100.0
1/2 inch (12.5 mm)	81	94
No. 8 (2.36 mm)	42	70
No. 16 (1.18 mm)	29	43
No. 30 (600 µm)	19	34
No. 50 (300 µm)	11	20
* No. 200 (75 µm)	2	8

n. Mineral filler shall consist of pulverized soil, pulverized crushed rock, broken stone, gravel, sand-gravel, sand or a mixture of these materials that conforms to the following requirements.

Table 1028.10
Mineral Filler for Type SPS

	Min.	Max.
Total Percent Passing the No. 50 (300 µm) Sieve	95	100
Total Percent Passing the No. 200 (75 µm) Sieve	80	100
Plasticity Index (material passing the No. 200 (75 µm) Sieve, except soil)	0	3
Plasticity Index for Soil	0	6

3. Contractor's Lab Equipment:

a. The Contractor shall calibrate and correlate the testing equipment according to the procedures prescribed for the individual tests and conduct tests in conformance with specified testing procedures.

b. The Contractor shall have the following equipment (or approved equal) at or near the project location:

- (1) An AASHTO approved gyratory compactor and molds.
- (2) An AASHTO approved Asphalt Content Ignition Oven.
- (3) Rice equipment
- (4) FAA equipment

(5) To test density of compacted asphaltic concrete, a minimum 6000 gm balance, 0.1 gm resolution, with under body connect and water container large enough to conveniently place specimen in the basket and completely submerge the basket and specimen without touching the sides or bottom is required.

(6) QC Laboratory (suggested size 8 ft. x 45 ft.) (2.4 m x 13.7 m) which contain the following:

- Air conditioner.
- Dedicated phone (where available).
- FAX machine.
- Xerox type copy machine.
- Sample storage.
- Work table.
- Bulletin board.
- Running water.
- Desk and chair.
- Separate power supply.
- Incidental spoons, trowels, pans, pails.

(7) Diamond saw for cutting cores.

(8) Diamond core drill (6 inch (150 mm) and 4 inch (100 mm) diameter core.

(9) Oven, 347°F (175°C) minimum, sensitive $\pm 5^{\circ}\text{F}$. ($\pm 2^{\circ}\text{C}$).

(10) USA Standard Series Sieves for coarse and fine aggregate with appropriate shakers [12 inch (300 mm) recommended].

(11) Personal Computer and Color Printer.

1028.03 -- Acceptance Requirements

1. Volumetric Mix Design

a. The job mix formula shall be determined from a mix design for each mixture. A volumetric mixture design in accordance with the latest edition of the Asphalt Institute Publication, SP-2, will be required. However, the mixture for the Superpave specimens and maximum specific gravity mixture shall be short-term aged for two hours.

(1) Practice for Short and Long-Term Aging of Hot Mix Asphalt (HMA), AASHTO TP2

(2) Practice for Volumetric Analysis of Compacted Hot Mix Asphalt, AASHTO PP19

(3) Method for Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor, AASHTO TP4

b. The optimum binder content shall be the binder content that produces 4.0 percent air voids at Ndes. The design shall have at least four points, including a minimum of two points above and one point below the optimum. The amount of uncompacted mixture shall be determined in accordance with AASHTO T209.

c. Changes in the types or sources of aggregates shall require a new job mix formula, mix design and moisture susceptibility test. The new proposed job mix formula shall be in accordance with the requirements as stated above and submitted 5 working days prior to use for approval.

d. Each Superpave mixture shall be tested for moisture susceptibility in accordance with AASHTO T283. The loose mixture shall be short-term aged for two hours in accordance with AASHTO TP2. The 6-inch specimens shall be compacted in accordance with AASHTO TP4 to seven percent air voids and evaluated to determine if the minimum Tensile Strength Ratio (TSR) of 80 percent has been met. If the mixture has not met the minimum TSR value, an anti-stripping additive shall be added to the mix at a dosage rate, such that the mix will meet the minimum TSR of 80 percent. All data shall be submitted with the mix design for approval. Moisture susceptibility testing is not required for Asphaltic Concrete Type SPS.

(1) Moisture susceptibility tests will be for mix design approval only. If tests for mix design approval indicate the need for an anti-stripping additive, then the Contractor shall be compensated for the cost of the additive needed.

e. Design Criteria:

(1) The target value for the air voids of the asphaltic concrete design shall be 4 percent at the Ndes number of gyrations.

Table 1028.11
Gyratory Compaction Effort
(Average Design High Air Temperature \leq 39 degrees C)

Asphaltic Concrete Type	Nini	Ndes	Nmax
SPS	6	40	62
SP0	6	50	74
SP1	7	68	104
SP2	7	76	117
SP3	7	86	134
SP4	8	96	152
SP5	8	109	174

(2) The design criteria for each mixture shall be determined from Tables 1028.12, 1028.13, and 1028.14.

Table 1028.12

Mix Criteria	SPS,SP0,SP1	SP2	SP3,SP4,SP5
Voids In Mineral Aggregate	See Table 1028.13		
Voids Filled with Asphalt	See Table 1028.14		
%Gmm at Nini	91.5*	90.5	89.0
%Gmm at Nmax	98.0*	98.0	98.0

* No specification requirement for SPS, only %Gmm at Ndes = 95 to 98.5

Table 1028.13
Voids in Mineral Aggregate
Criteria at Ndes

Nominal Maximum Aggregate Size (Metric)	Minimum VMA, Percent*
3/8 inch (9.5 mm)	15.0
1/2 inch (12.5 mm)	14.0
3/4 inch (19 mm)	13.0
1 inch (25 mm)	12.0
1 1/2 inch (37.5 mm)	11.0

* No specification requirement for SPS

Table 1028.14
Voids Filled with Asphalt
Criteria at Ndes

Asphaltic Concrete Type	Design VFA, Percent
SPS	N/A
SP0	70 – 80
SP1	70 – 80
SP2	65 – 78
SP3	65 – 78
SP4	65 – 75
SP5	65 – 75

2. The Contractor shall make Mix adjustments when:

- a. Air voids, VMA, VFA, FAA, CAA or Binder content do not meet the currently approved criteria.
- b. Surface voids create a surface and/or texture which does not meet the criteria of Sections 502 and 503 in the 1997 English and Metric Edition of the Standard Specifications.
- c. Pavement does not meet any other design criteria.
- d. Rutting occurs.

3. Mix adjustments at the plant are authorized within the limits shown in Table 1028.15 without redesigning the initially approved mix:

- a. The adjustment must produce a mix with the percent air voids required.
- b. All adjustments must be reported to the Engineer.

Table 1028.15

Aggregate Adjustments	
Sieve Size	Adjustments
1 inch (25 mm), 3/4 inch (19 mm), 1/2 inch (12.5 mm), 3/8 inch (9.5 mm)	± 6%
No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No.50 (300 µm)	± 4%
No. 200 (75 µm)	± 2%

c. The adjustment values in Table 1028.15 will be the tolerances allowed for adjustments from the NDR verified mix design “Combined Gradation” target values which resulted from production or mix design adjustments, but cannot deviate from Superpave gradation criteria, or pass through the restricted zone when the mix FAA value is less than 45.

4. Sampling and Testing:

- a. The Contractor shall take samples at locations identified by the Engineer, according to the NDR statistically-based procedure. The samples

shall be approximately 75 pounds (34 kg), transported to the test facility in an insulated container and split according to NDR T-248.

b. All samples and companion samples within a Lot shall be identified, stored, and retained by the Contractor until the NDR has completed the verification testing process.

c. (1) The sample shall be taken from the roadway, behind the paver before compaction.

(2) At least one QC sample shall be tested for every 750 tons (680 Mg) of plant produced mix.

(i) If, at the completion of the project, the final lot consists of less than 3,750 tons (3,400 Mg) of asphaltic concrete, 1 sample for each 750 tons (680 Mg) or fraction thereof, shall be taken and tested.

(3) Additional sampling and testing for the Contractor's information may be performed at the Contractor's discretion. Any additional testing will not be used in pay factor determination.

(4) At the project start-up and when a substantial aggregate proportion or other major mix change has been made, at least 1 sample shall be taken from the first 300 tons (270 Mg) of production.

(5) At least one CAA and FAA sample shall be taken and tested daily by the Contractor. The FAA and CAA may be sampled from the blended cold feed material but in addition the Contractor will be required to test FAA and CAA from a roadway sample using an ignition oven sample for correlation. If the coarse portion of the blend is all ledge rock the CAA tests can be waived. If the samples tested with the ignition oven meets the CAA and FAA minimum requirement, then the cold feed sample does not have to be tested.

(6) For projects using RAP material the FAA shall be established as follows:

A RAP sample will be processed through an ignition oven and then combined with the proportioned amount of virgin aggregate defined by the mix design and then proceeding with the FAA testing.

d. Samples should not be taken from the first 110 tons (100 Mg) of mix produced or after a significant mix change.

e. The sample shall be compacted immediately while still hot (additional heating may be required to raise the temperature of the sample to compaction temperature).

f. Each production sample shall be tested as follows:

(1) (i) Bulk Specific Gravity (Gmb) shall be determined for each specimen in accordance with NDR T 166 - Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens.

(ii) The 3 specimen results are averaged for each sample.

(iv) At the Contractor's request, upon evidence that the 3 Bulk Specific Gravity specimens are exhibiting consistency in their results, The Materials and Research Central Laboratory may reduce the number of specimens to 2.

(3) (i) The Blended Aggregate Bulk Specific Gravity (Gsb) shall be determined from the individual aggregate component bulk specific gravity's.

Aggregate. (iii) AASHTO T 85 - Specific Gravity and Absorption of Coarse

$$G_{sb} = \frac{P_1 + P_2 + P_3 + P_4 + P_n}{G_1 + G_2 + G_3 + G_4 + G_n}$$

P_1, P_2, \dots, P_n = Mass or percentages of aggregates
 G_1, G_2, \dots, G_n = Bulk specific gravity's of individual aggregate components.

NOTE: G_{sb} need not be recomputed for each production sample, but only after a significant aggregate proportion change.

Table 1028.17

$$\text{Gmb}(\text{corr})@N_{any} = \text{Gmb}(\text{meas})@N_{max} \times \left(\frac{\text{height}@N_{any}}{\text{height}@N_{max}} \right)$$

$$\% \text{Gmm}(\text{corr})@N_{any} = 100 \times \left[\frac{\text{Gmb}(\text{corr})@N_{any}}{\text{Gmm}(\text{meas})} \right]$$

$$\% \text{Air Voids}@N_{any} = 100 - \% \text{Gmm}(\text{corr})@N_{any}$$

$$\text{VMA}@N_{des} = 100 - [\text{Gmb}(\text{corr})@N_{des} \times P_s + G_{sb}]$$

$$\text{VFA}@N_{des} = 100 \times \left[\frac{(\text{VMA}@N_{des} - \% \text{Air Voids}@N_{des})}{\text{VMA}@N_{des}} \right]$$

Measured = (meas)

Corrected = (corr)

(5) The percent of PG Binder shall be determined for each production day or portion of a day. The percent of PG Binder is based on the total weight of the PG Binder used, based on the tank stab, divided by the total asphaltic concrete mix's weight.

(6) Except as noted in this Subsection, all sampling and testing shall be done as prescribed in the *NDR Materials Sampling Guide and Standard Method of Tests*.

g. Testing Documentation:

(1) All test results and calculations shall be recorded and documented on data sheets approved by the Engineer.

(2) Specific test results shall be recorded on a daily summary sheet provided by the NDR to facilitate the computation of moving test averages.

(3) Moving averages shall be based on 4 consecutive test results, except for the theoretical maximum specific gravity (Rice) which will be based on single test results.

h. QC Charts:

(1) QC charts shall be posted at the asphalt production site and kept current with both individual test results and moving average values for review by the Engineer.

(2) Control charts shall include a target value and specification limits.

(3) As a minimum, the following values shall be plotted or reported on NDR provided forms as indicated below:

(i) Laboratory Gyratory density (each point being an average of 3 specimens) will be reported.

(ii) Ignition oven or cold feed aggregate gradations for all Superpave sieves will be reported.

(iii) PG Binder content shall be plotted to the nearest 0.1 percent by ignition oven results in accordance with AASHTO TP 53.

(iv) The theoretical maximum specific gravity (Rice) to the nearest 0.001 percent will be reported.

(v) Laboratory Gyratory air voids at Ndes shall be plotted to nearest 0.1 percent. Laboratory Gyratory air voids, at Nini, Ndes and Nmax shall be reported to nearest 0.1 percent.

(vi) FAA and CAA of the asphaltic concrete for both cold feed and ignition oven samples will be reported to the nearest 0.1 percent.

(vii) VMA content shall be plotted to nearest 0.1 percent and VFA shall be reported to the nearest 0.1 percent.

i. Independent Assurance (IA) Review of Testing:

(1) The Contractor will allow NDR personnel access to their laboratory to conduct IA review of technician testing procedures and apparatus. Any deficiencies discovered in testing procedures will be noted and corrected.

(2) During IA review, NDR personnel and the Contractor will split a sample for the purpose of IA testing. The sample(s) selected will be tested in the NDR Branch Laboratory. Any IA test results found to be outside of defined testing tolerances will be noted. The Contractor must then verify the testing apparatus and make connections if the apparatus is out of tolerance.

(3) Testing Tolerances

(i) Asphaltic Concrete and Asphaltic Concrete Aggregates.

Test	Tolerance
Asphalt Content by Ignition Oven	0.5%
Gyratory Density	0.02
Maximum Specific Gravity	0.015
Bulk Dry Specific Gravity (for Mix Design)	0.028
FAA	0.5%
CAA	10.0%

(4) Aggregate Gradation (Blended Aggregate)

Size Fraction Between Consecutive Sieves, %	Tolerance
0.0 to 3.0	2%
3.1 to 10.0	3%
10.1 to 20.0	5%
20.1 to 30.0	6%
30.1 to 40.0	7%
40.1 to 50.0	9%

5. a. In response to tests results, the Contractor shall notify the Engineer whenever the process approaches the *Specification* limits.

b. Two consecutive points outside the *Specification* limits or a (50% or reject) shall be cause to cease operations.

c. The Contractor shall assume the responsibility to cease operations.

d. The process shall not be started again without approval of the Engineer.

e. Failure to cease operations after 2 consecutive points fall outside the *Specification* limits shall subject all subsequent material to be rejected.

6. Verification Sampling and Testing:

a. The NDR will select and test at random one of the subplot samples (750 tons, 680 Mg) within a Lot (3750 tons, 3400 Mg) for verification and report results in a timely manner.

b. The results of Contractor QC testing will be verified by NDR verification tests. On any given Lot, if the results of Air Void verification testing and its companion QC testing are within 1.4 percent air voids, the Air Void verification for the entire Lot is complete and the Contractor test results will be used to determine the pay factors. If the Air Void verification test results and the companion QC test results are outside the above tolerance, the results from the verification test will be used to determine the pay factor for that subplot. Any or all of the remaining four NDR subplot samples may be tested and the NDR subplot test results may be applied to the respective sublots and the resulting pay factors will apply.

c. When verification test results show a consistent pattern of deviation from the QC results, the Engineer may cease production and request additional verification testing or initiate a complete IA review.

d. If the project personnel and the Contractor cannot reach agreement on the accuracy of the test results, the Materials and Research Laboratory will be asked to resolve the dispute, which will be final.

7. Acceptance and Pay Factors

a. Acceptance and pay factors for Asphaltic Concrete Type SPS will be based on compacted in place average density.

b. Acceptance and pay factors for Asphaltic Concrete Type SP0, SP1, SP2, SP3, SP4 and, SP5 will be based on single test air voids, running average air voids and compacted in place average density.

(1) These three individual pay factors will be multiplied by each other to determine a total pay factor for each subplot [(750 tons) (680 Mg)].

8. Asphaltic Concrete Air Voids

a. Normally, 1 sample for testing will be taken from each subplot [(750 tons) (680 Mg)] at locations determined by the Engineer.

b. The pay factors for the single test air voids and moving average of four air voids pay factors will be determined in accordance with table 1028.18.

c. If the average air voids pay factor is (50% or reject) the NDR will have the first option of accepting or rejecting the asphaltic concrete represented in this subplot. If the NDR accepts this subplot the Contractor will have the second option of replacing this asphaltic concrete for no pay on the removal and for whatever pay factor that applies to the replacement.

d. In the case of removal, the foremost limits of the removal will be defined as the tonnage (mass) at which the production and placement was halted and a design change was made. The rear limits will be at the tonnage (mass) where linear interpolation with the previous test return to an accepted range and out of rejection limits or at the limit(s) of the defective material as determined by additional core samples taken and tested by the Contractor which show result(s) in an acceptable range and out of rejection limits to the satisfaction of the Engineer.

Table 1028.18

Acceptance Schedule Air Voids - N_{des}		
Air voids test results	Moving average of four	Single test
Less than 1.5%	Reject	Reject
1.5% to less than 2.0%	Reject	50%
2.0% to less than 2.5%	50% or Reject	95%
2.5% to less than 3.0%	90%	100%
3.0% to less than 3.5%	100%	100%
3.5% to 4.5%	102%	102%
Over 4.5% to 5.0%	100%	100%
Over 5.0% to 5.5%	95%	100%
Over 5.5% to 6.0%	90%	95%
Over 6.0% to 6.5%	50% or Reject	90%
Over 6.5% to 7.0%	Reject	50%
Over 7.0%	Reject	Reject

9. Asphalt Concrete Density Samples:

a. Density tests will be performed by the Contractor under direct observation of NDR personnel. The Contractor will establish the method of testing in the preconstruction conference and shall be tested in accordance with the NDR T 166 or NDR T 587. The Contractor will insure that the proper adjustment bias and/or correction factors are used and accessible to NDR personnel along with all other inputs when NDR T 587 is selected. All disputed values determined using NDR T 587 shall be resolved using NDR T 166.

b. Density of samples shall be determined by comparing the specific gravity of the core sample to the Maximum Specific Gravity (Rice) as follows:

$$\% \text{ Density} = \frac{\text{Specific Gravity of Core}}{\text{Maximum Mix Specific Gravity (Rice)}} \times 100$$

where:

$$\text{Sp. Gr. of Core} = \frac{\text{Wt. of Core in Air}}{\text{Wt. of SSD Core} - \text{Wt. of Core in Water}}$$

$$\text{Maximum Mix Specific Gravity (Rice)} = \frac{\text{Wt. of Mix in Air}}{\text{Wt. of Mix in Air} - \text{Wt. of Mix in Water}}$$

Note: The Maximum Mix Specific Gravity (Rice) value used to calculate the density of each core shall be the average value determined by the Contractor for the day's production that the core represents. If only 1 or 2 Maximum Mix Specific Gravity (Rice) values are determined in a given day then the value used will be the moving average value at the end of that day's testing.

c. Either 4 inch (100 mm) or 6 inch (150 mm) diameter core samples shall be cut by the Contractor the first day of work following placement of the mixture.

d. Normally, 1 sample for determination of density will be taken from each subplot (750 tons) (680 Mg) at locations determined by the Engineer.

e. The theoretical maximum density for each lot (3,750 tons) (3,400 Mg) shall be calculated using AASHTO T 209.

f. The average density of the lot shall be used to compute the pay factor for density. Exceptions to the sampling and testing of core samples for the determination of density are as follows:

(1) When the nominal layer thickness is 1 inch (25 mm) or less, the sampling and testing of density for this layer will be waived.

(2) When the average thickness of the 5 cores for a lot is 1 inch (25 mm) or less, the testing of density samples for this lot will be waived.

(3) When the nominal layer thickness and the average of the original 5 cores for a lot are both more than 1 inch (25 mm), but some of the cores are less than 1 inch (25 mm) thick, additional cores shall be cut at randomly selected locations to provide 5 samples of more than 1 inch (25 mm) thickness for the determination of the pay factor for density.

g. For the first lot (3,750 tons) (3,400 Mg) of asphaltic concrete produced on a project and for asphaltic concrete used for temporary surfacing, the pay factor for density shall be computed in accordance with Table 1028.19. After the completion of the first lot, the pay factor for density shall be computed in accordance with Table 1028.20.

h. (1) If, at the completion of the project, the final lot consists of less than 3,750 tons (3400 Mg) of asphaltic concrete, a minimum of 3 samples, or 1 sample for each 750 tons (680 Mg) or fraction thereof, whichever is greater, shall be taken and tested for density.

(2) The test results shall be averaged and the density pay factor based on the values shown in Table 1028.20.

(3) Should the average of less than 5 density tests indicate a pay factor less than 1.00, additional density samples to complete the set of five shall be taken at randomly selected locations and the density pay factor based on the average of the 5 tests.

Table 1028.19

Acceptance Schedule Density of Compacted Asphaltic Concrete (First Lot)	
Average Density (5 Samples, Percent of Voidless Density)	Pay Factor
Greater than 90.0	1.00
Greater than 89.5 to 90.0	0.95
Greater than 89.0 to 89.5	0.70
89.0 or Less	0.40 or Reject

Table 1028.20

Acceptance Schedule Density of Compacted Asphaltic Concrete (Subsequent Lots)	
Average Density (5 Samples, Percent of Voidless Density)	Pay Factor
Greater than 92.4	1.00
Greater than 91.9 to 92.4	0.95
Greater than 91.4 to 91.9	0.90
Greater than 90.9 to 91.4	0.85
Greater than 90.4 to 90.9	0.80
Greater than 89.9 to 90.4	0.70
89.9 or Less	0.40 or Reject

i. If requested by the Contractor, one complete set of check tests or one check test for any individual low density test in the original set, taken no later than the working day following placement, or not later than when traffic will allow will be allowed in lots with a density pay factor of less than 1.00. The average density obtained by substituting the check tests for the original tests shall be used to establish the density pay factor for the lot.